Rebuilding Critical Energy Assets in Times of Disaster: Strategies for a Resilient System

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Introduction

The back-to-back disasters that captivated and horrified the American public; the September 11th attacks, the Northeast power blackout of 2003, and Hurricanes Katrina (2005) and Ike (2008), bombarded America with images of sacrifice and survivors. The ever present emergency worker has been proclaimed the hero of the early 21st century. Outside of these iconic images, little thought is given to the primary backbone of the support network that springs into action after a large scale disaster, energy. Without energy, in the form of electricity and fuel, there would be no relief workers, little or no sanitation, and for all intents and purposes, the survivors would be stranded.

The dependence of the natural gas and oil sector on electricity is little understood. Until very recently, the integrity of the energy grid and its ability to withstand disruption has not been given close scrutiny. Electricity is needed at almost every stage of energy production and supply; to pump gasoline, and then move oil and natural gas through pipelines. Further highlighting our dependence on electricity, homeowners often have furnaces and natural gas water heaters with electric ignition.

The wide publicity of the aforementioned disasters and the highlighting of governmental relief failures have ushered in a new awareness of the need to protect critical infrastructure and energy assets, without which, no recovery would be possible. Rapid setup of energy systems in the immediate aftermath of a disaster is now understood to determine the trajectory of recovery.

The fundamental thesis of this article argues that large scale energy disruptions can be prevented and made practically impossible by the incorporation of a resilient and flexible system. Although there is focus and awareness of energy security in relation to our oil imports, this has misdirected the public into thinking that if we diversify our oil imports or increase domestic drillings, we are "safe" from energy disruptions.

Reliance on petroleum based energy security externally focused, has switched our dependence closer to home, and has left our eyes closed to the enormous threat of domestic energy disruption. The US energy infrastructure is vulnerable in its very core; the following detail the critical chokepoints of our national energy grid.[10]

- Increased system complexity increases the total vulnerability of the energy grid.
- Over reliance on telecommunication and information technology to regulate the network.
- Interdependence of the entire system, when one portion of the system shuts down, it ripples throughout the system.
- Specialized equipment requirements

[10] Amory B. Lovins, *Critical Issues in Domestic Energy Vulnerability, About Clean Energy Roundtable VIII* Montreux Energy (Oct. 08, 2001)

- The repair of the system requires a specialized knowledge base, and is juxtaposed with a persistent lack of advanced spare parts.

Section 1 makes the case as to why a decentralized energy network is needed in the United States. Section 2 describes the history of the national energy grid and discusses how it developed into its current form. Section 2 further delineates the path of deregulation that began in the 1970s and the return to regulation in many states. Section 3 analyzes decentralized energy assets and discusses how their incorporation will add much needed flexibility to the national energy grid. Section 4 considers the role of decentralized energy assets in a disaster area, and how their practical use may increase the speed at which a devastated community returns to normal. Section 5 concludes by illustrating how the incorporation of a decentralized energy matrix in the national energy policy will serve to protect the country from the brunt of large scale man-made and natural disasters.

The Case for a Decentralized Energy System

The nation's power network is made up of a large centralized network that operates relatively efficiently in times of ease, however, when a problem occurs somewhere in the network; it rapidly cascades throughout the system, as happened during the Northeast blackout of 2003.[11] The US energy grid, of which electricity generation is one portion, can quite accurately be characterized as brittle and fragile. The US energy grid is highly centralized, and thus extremely vulnerable to system disruption from failure of one of its constituent parts. Three-fourths of oil produced in the US comes from just four states, Texas, Alaska, Louisiana, and California.[12] And half of the nation's refinery capacity is located is concentrated in three states, Texas, Louisiana, and California and three fifths of the nation's petrochemical base is located in just one state, Texas.[13] A disaster centered in this critical region can have nationwide consequences.

The design of this dysfunctional system was not through malice, but the result of a slight myopia in creating a system that was designed to deliver cheap energy in a utopia, where periodic hurricanes, terrorist attacks and other disruptions are nonexistent. The energy grid was constructed part by part without consideration that as the system gains in complexity, it gains in fragility. The US energy grid is notoriously intricate,

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[11] The Northeast Blackout of 2003 was a widespread power outage that occurred throughout parts of the Northeastern and Midwestern United States, and Ontario, Canada on Thursday, August 14, 2003. Until that time, it was the largest power outage in the history of the United States, affecting approximately 50 million energy consumers in the US and Canada, with financial losses reaching upwards of $6 billion. See New York Independent System Operator, *Blackout August 14, 2003 Final Report* New York Independent System Operator (Feb. 2005) Available at
<http://www.nyiso.com/public/webdocs/newsroom/press_releases/2005/blackout_rpt_final.pdf>

[12] One of the first scholars to point out the fragility of the US power grid was Chairman and Chief Scientist of the Rocky Mountain Institute, Amory Lovins. Lovins in 1982 published his groundbreaking book co-authored with L.Hunter lovins, *Brittle Power: Energy Strategy for National Security,* that argues the domestic energy infrastructure is extremely vulnerable to disruption, more so than imported oil. Lovins main thesis is that a resilient, flexible system is more inexpensive and feasible than our current centralized system, but US policy makers reject this contention. See generally, Amory B. Lovins and L. Hunter Lovins, *Brittle Power: Energy Strategy for National Security* (1982).

[13] Ibid.

consisting of an interdependent system of aerial wires, shallowly buried pipelines, oil refineries, fuel-storage facilities, and enormous power plants systems.[14]

The primary problem of the energy grid is the lack of flexibility to rapidly respond to disruption in the form of disaster, man-made or otherwise. And yet, even with the focus on terrorism striking the heartland, our energy system remains vulnerable to disruption. Essentially, even though the Department of Energy has been given an antiterrorism mandate, the very design of the nation's energy arteries has circumvented true disaster preparedness.

The energy grid's vulnerabilities were placed in startling relief when Hurricane Ike struck in September, 2008. Ike left fuel shortages that spread throughout the Southern US for several weeks. And hurricane Katrina aptly illustrated that without energy, life in the US can quickly resemble the poorest of developing nations.[15] The modern energy infrastructure is so complex that it may be impossible to foresee the ways it which it may collapse. Almost every significant energy disruption has come as a surprise to the power system administrators and designers. Engineers tend to be quite proficient when designing a system to deal with predictable failures, however, a system that deals well with predictable failures, tends to fail spectacularly with unforeseen ones.[16] The key to a dependable energy infrastructure is one that is flexible and resilient system, and incorporates independent, discrete units.

Renewable energy can also play a very important role in fostering reliability. A variety of energy sources that serve a smaller population, closer to end users, would actively work to insulate an area from an enveloping blackout. When renewable energy sources fail, they generally fail for less time than larger power plants.[17] Renewable sources of energy tend to fail because of predictable effects, such as cloud cover, lack of wind, drought and Earth rotation.[18] Disruption of non renewable sources generally has an air of uncertainty, such as devastating hurricanes, labor strikes, terrorism, and reactor problems.[19] Furthermore, the placement of power generation systems near the end-user would increase energy efficiency by mitigating the energy lost by the long distance transmission.

The Origins of the Grid: The Birth of a Monopoly

The national energy grid was developed in the era of heavy industrialization, not the era of the microprocessor. An added complication was the market deregulation that occurred within the past few decades, moving from a regulated monopoly to an industry following more of a free market competitive model. One of the original regulatory laws

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[14] Amory Lovins and L. Hunter Lovins, *The Fragility of Domestic Energy*, The Atlantic (Nov. 1983) p. 119

[15] Edward J. Clay, *Hurricane Katrina, a Third Would Disaster?*, Create Symposium: University of Southern California (Aug. 19-20, 2006)

[16] On the ramifications of not taking into account potential occurrences into disaster planning. *See* generally Nicholas Naseem Taleb**,** *The Black Swan: The Impact of the Highly Improbable* (2007)

[17] Supra Note 5, *The Fragility of Domestic Energy* p.124

[18] Ibid. Although it must be stated that even wind generation based on a centralized model can have its mega failures. On February 28, 2008, Texas operators narrowly averted a major rolling blackout after sudden drop in West Texas wind. The shortage was prompted largely by a near-total loss of wind generation, as well as a failure of several energy providers to reach scheduled production and a spike in electricity usage. See *State Almost Saw Rolling Blackouts on Tuesday Night*, The Dallas Morning News, (Feb. 28, 2008)

[19] Supra Note 5, *The Fragility of Domestic Energy* p.124

that set the mold of the regulatory legal structure was the Public Utility Holding Company Act (PUHCA) which was promulgated in 1935. Under the PUHCA, every aspect of electricity, from generation to transmission was regulated by authorities.

When the electrical grid was first developed, and up until the beginning of market deregulation in the 1970s, electric utilities were primarily local operations. During the Progressive Era prior to World War One, electricity consumption was designated a public good, a basic necessity to modern life. In many areas, electrical generation and transmission facilities were for all purposes public property, usually managed by municipal officials. In other areas, privately owned utilities were granted monopoly status, but regulatory frameworks were set up to ensure that excessive rates were not charged to consumers. Each utility was vertically integrated, undertaking the supply of the entire supply chain from electricity supply to distribution. The utility controlled the three main components of electricity, power generation, power transmission, and power distribution.

The transmission line was constructed to serve the local community with some flexibility incorporated to assist nearby utilities in case of emergencies. The electrical utilities that supported the transmission system were allowed to pass costs on to customers, and as transmission lines were necessary for consistent operation, they tended to be kept in good repair. The monopoly system did have some benefits as well. Monopoly status enabled the utility to predict with reasonable accuracy the future growth in power demand, enabling it to plan its capital upgrade investment. Thus, it engendered a predictable return on the long-term investment, which was necessary for constructing large scale, expensive generating systems.

But the disadvantages of such a system are clear as well, because of a guaranteed rate of return by the regulator, utilities had little incentive to rein in costs or to encourage energy conservation. A guaranteed set return on investment gave them reason to spend enormous sums on huge facilities, in particular on nuclear plants, while not considering environmental concerns too highly.

The Path to Deregulation

During the 1970s, deregulation was touted as being the solution to industry ills. From trucking, airlines, natural gas, banking, health care and telecommunications, the governmental focus was on how best to liberalize these markets to deliver benefits to the middle class end user. In the electricity sector, the law that precipitated partial deregulation of the energy sector was the Public Utilities Regulatory Policy act of 1978 (PURPA). PURPA created a market for non-utility electric power producers by forcing the major utilities to buy power from these producers at the “avoided cost” rate, which is the cost the electric utility would incur were it to generate or purchase the power from another source.[20]

PURPA created a new class of energy producer designated a “qualifying facility,” which is small scale commercial energy producer who normally self-generate electricity for its own needs but may occasionally have surplus energy. The core of this new system is what is known as retail wheeling, which creates an open market for electric power, and theoretically enables any consumer to purchase electricity from any supplier. The

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[20] Janice A. Beecher, *Avoided Cost: An Essential Concept for Integrated Resource Planning*, Center for Urban Policy and the Environment. Available at < http://www.ucowr.siu.edu/updates/pdf/V104_A7.pdf>

"wheel" aspect of it means that an independent power producer can produce electricity to flow directly onward to the buyer.[21]

The Flowering of the Tree and the Fruits of Deregulation

A widely maligned failure of deregulation is that at least under a monopoly framework, there is a strong desire to take care of the utilities' own consumers, and for the utility to make certain that the transmission and distribution system is in good repair. However, the transformation of a nation-wide grid into many competing small entities, which lack ownership of the transmission system, changed the system significantly. Under such a deregulated system, companies have few incentives to maintain the transmission lines, because the power provider generally does not own the lines that transport its electricity.

Furthermore, there tends to be overuse of interconnecting transmission lines between utilities. Prior to the deregulatory phase, the interconnecting lines were primarily designed for emergency use, however, once deregulation happened apace, the transmission lines between the utilities were put into much more constant use, which strained the system. Deregulation also brought more rapid on-and-off cycling of power plants which increased the rate of the physical deterioration of the electricity infrastructure. This rapid cycling caused the metal parts to become heated and cooled more often then they normally would.[22]

And finally, there was much more transmission line congestion, deregulation brought more long distance trading, which then caused a need for more long distance transmission lines. But because of a profound lack of incentive to invest in these lines for power companies, as well as well organized community opposition against the placement of the transmission lines placed in their community, caused a great deal of congestion. In the last decade, US power demand has surged by 30% in the last decade, while the transmission capacity has grown by only 15%. Thus, during normal conditions the transmission lines are running close to capacity, and when an extreme disaster strikes, there is not enough slack in the system to compensate.[23]

It is perhaps not deregulatation itself, but the method in which it was conducted that left the national grid vulnerable. Bill Richardson, former Energy Secretary during the Clinton administration characterized the US as being ""a superpower with a Third World [power transmission] grid,"[24] echoing that statement, President Bush called for investment in the "antiquated" electrical grid system. [25]

The Return of Regulation

Some states are now attempting to reverse deregulation, due, in part, to a fear of public backlash over its failures. For example, the Illinois legislature approved in September, 2008, an $11 billion rate relief framework that will lower the rate increases

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[21] See Kenneth Costello, *How State Regulators Should Handle Retail Wheeling*, Public Utilities Reports, Inc. (Feb. 15, 1995)

[22] Gail Tverberg, *The US Electric Grid: Will it be our Undoing*?, Energy Bulletin (May 7, 2008)

[23] As is happening with increasing frequency. On October 29, 2008, a large snowstorm cut off power to thousands of residents in the Northeast, stretching from Vermont to New Jersey. See *Northeast Storms Cut Power to Thousands*, Associated Press (Oct. 29, 2008)

[24] *What Caused the Blackouts*?, BBC News (Aug. 15, 2003)

[25] *Bush Urges US Grid Upgrade*, BBC News (Aug. 15, 2003)

caused by deregulation by half.[26] The framework will also eliminate a very controversial wholesale-power auction system and will found a new agency to purchase electricity and build generators. Other states have followed the trend; Virginia has reregulated its power sector in July, 2008, while other states are in the process. Ohio rate freezes are officially scheduled to end in December, 2008, and officials there are weighing the possible extension of rate freezes.

Representative of the public feeling that the market has failed to deliver the promised benefits of deregulation, Ohio Governor Ted Strickland publicly stated that "some feel you should let the market take over, but based on what I've seen happen in other states, it's just not something I'm willing to tolerate."[27] The public revolt that Strickland was referencing is centered around the fact that average rate increases increased by 21 percent in regulated states from 2002 to 2006, but in deregulated states where rate caps expired, they surged to 36 percent, while little or no competition arose. [28]

Although as a caveat, it must be noted that one of the reasons for the extreme price increases may be the increase of fossil fuel prices, especially natural gas, which exerted a distinct upward pressure on utilities' costs.[29] A wave of public opposition to coal burning plants for both aesthetic reasons and global warming concerns led to more reliance on natural gas, which correspondingly caused electricity prices to increase in tandem with natural gas prices.[30]

However, there is suspicion that the primary factor behind the electricity price increase has not been the increase in the natural gas price.[31] The suspicion is that most big utilities and their power generation affiliates have not built transmission lines to import out of state electricity because of a vested interest in keeping gas supplies tight,[32] although a portion of the blame for the lack of competition is placed on the state paradoxically attempting to protect the consumer by freezing residential rates for five to ten years while deregulation proceeds. Thus, while 60 percent or more of commercial customers switch to new entrants, less than 10 percent of residential customers did so.[33] Many blame the state regulators, that by shielding the consumers with low regulated prices, they did not allow competition to work.[34] Whereas as exemplified in Texas, when utilities have been able to raise their rates in tandem with fuel price increases, and were

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[26] Paul Davidson, *Shocking Electricity Prices Follow Deregulation*, USA Today (Oct. 29, 2008)
[27] Ibid.
[28] William A .Niskanen, *A Case Against Both Stranded Cost Recovery and Mandatory Access*, Regulation, (1996) p. 16-17
[29] For example, natural gas prices tripled in the late 1990s and the early part of 2000.
[30] Concerns about global warming have intensified in the financial sector. Three large investment banks, Citigroup, JP Morgan Chase, and Morgan Stanley, announced that in evaluating new coal burning plants, they would take into account potential future charges for carbon dioxide emissions. They reiterated that they would not block funding, but would investigate the future viability and the potential for large carbon costs before agreeing to underwrite these projects. See Matthew L. Wald, *Utilities Turn from Coal to Gas, Raising Risk of Price Increase*, New York Times (Feb., 5, 2008)
[31] Supra note 5, *Shocking Electricity Prices Follow Deregulation*.
[32] Ibid.
[33] Ibid.
[34] Ibid.

liberated from price ceilings, 60 percent of Texas consumers chose an alternative supplier.[35]

Virginia, in joining the wave of states rolling back deregulation, has given utilities new incentives to build power plants, and ended retail choice for many of the residential users, to be able to ensure a suitable customer base to finance the building of new generators.

The Creation of Grid Flexibility: Decentralized Energy Assets

Decentralized energy assets (DEA) are generally defined as "[E]electricity production at or near the point of use, irrespective of size, technology or fuel used - both off-grid and on-grid."[36] Further, they can be “grid-integrated, stand alone, deployable, dispatchable, and islandable.”[37] Examples of DEA range across a large variety of energy assets, such as electric generators, reciprocating engines, micro-turbines, turbines, fuel cells, solar panels; combined heat and power system, amongst many others.[38]

Given its popularity, decentralized energy may now be used with increasing frequency, but the concept is not new. A decentralized energy miniature-plant was first created on September 4, 1882, with the creation of the Pearl Street Station, the first power station in the world that provided electricity and heat to neighboring buildings.[39] What determines decentralized energy is not the fuel used in its production, but that the energy is produced onsite. In its strict definition, decentralized energy is not concerned with the type of fuel used, thus even fossil fuel generators can be claimed by decentralized energy. However, as discussed subsequently, renewable fuels forms the crux of a decentralized strategy. The basic concept underlying decentralized energy is that energy is produced when and where it is needed.

The small size of decentralized energy, which is usually less than 20 megawatts, enables it to quickly power up or down to meet the variability in utility loads. It also bolsters reliability because its transmission line is over shorter distances; as opposed to the long lines that central power plants use that often fails during hurricanes and other natural disasters.

The use of DEA will promote a more flexible, strong, and reliable electrical grid than the current centralized grid system. The strength of the system is not only confined to disasters, during ordinary times it will be able to produce clean energy, while lessening the strain on the central grid, and mitigating the large amount of energy loss that occurs over long distance transmission. The true strength of DEA lies in the ability to “island” efficiently. Islanding is the ability for the electrical grid to fragment into small, self-contained power generation areas in response to a significant disruption that ripples throughout the power grid. The fact that DEA is located close to the end users, a disaster that impacts an area, will only be felt locally, with local effects. Further, if a disaster strikes a far off centralized power plant, DEAs will be able to shield local communities from the impact of a regional grid collapse.

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[35] Supra note 5, *Shocking Electricity Prices Follow Deregulation*.

[36] This is the definition of the World Alliance for Decentralized Energy. Available at < http://www.localpower.org/deb_what.html>

[37] Protecting Critical Energy Infrastructure and Helping Communities Recover from Disaster with Distributed Energy Assets, *Distributed Energy Program* (2005)

[38] Ibid.

[39] Ibid.

DEA is also quite cost effective in the everyday management of the electrical grid by by relieving the demand burden on the national grid during peak times. And the incorporation of advanced electronics based power controls-otherwise known as smart controls- can assist in the management of the electricity flows. For instance, if a system is designed using FACTS (Flexible AC Transmission System), the system regulators will have the ability to control to mitigate cascading system failures in the wake of a massive disruption.[40]

Nuts and Bolts: How Decentralized Energy Assets Work

Decentralized energy has garnered the attention of the federal government and major power producers. North Carolina-based Duke Energy is pursuing a $100 million pilot program placing solar panels on an initial 850 houses, schools, and buildings to produce up to 16 megawatts generation capability.[41] Jon Wellinghoff, a member of the Federal Energy Regulatory Commission, said in reference to developing a decentralized energy system, that, “It is absolutely essential if we are going to have an intelligent grid operating at its optimal efficiency,"[42] He further elaborated that decentralized energy must play a role because as electricity demand rises, climate control regulations will play a much larger role in domestic energy production.

However, not all stakeholders support the development of decentralized energy. Some utilities and energy regulators think that the use of too many energy sources will make it difficult to balance the load on the transmission lines.[43] Further, critics state that utilities will find it difficult for their balance sheets, as state regulators almost uniformly require utility rates to be based on the amount of power that they sell, and on the company’s assets, which include power plants and the transmission and distribution system.[44]

Moreover, one of the largest obstacles to the development of a national energy grid based on many thousands or millions of small power generators is the lack of a digitized “smart grid” to handle the necessary two way communication between the utility and multiple power sources. The national electrical grid has its origins in the 1960s, and was built to power a heavy industrial society, not the computer and micro-processing reliant society we have today. To put it in perspective, our current grid was constructed before cell phones, microprocessors and microwave ovens. Further, system-wide modernization would require that the legal/regulatory structure that solidified over eighty years ago becomes more flexible.

Disaster Recovery: The Role of Decentralized Energy Assets

In the crucial period after a disaster, coordinated federal and local support is necessary to address the short term, immediate aftermath of an accident. In the crucial days afterwards, immediate action is needed to meet fundamental human needs and to preserve life and property. Energy emergency services can help the community return to

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[40] P. Asare, *et al*, *An Overview of Flexible AC Transmission Systems*, Purdue Library (1994) Available at < http://docs.lib.purdue.edu/ecetr/205>

[41] Katherine Ling, *The New Local Power Plant Just Might be Your House*, Greenwire. (Oct. 07, 2008)

[42] Ibid.

[43] David Morris, *Distributed Energy, First Wait on Transmission Lines*, Renewable Energy World (Aug. 28, 2008)

[44] Supra, note 32, The *New Local Power Plant Just Might be Your House.*

normal as quickly as possible. Although, policy needs to be constructed from the highest levels of government, local and municipal authorities are often the first ones to react and have access to vital information on the ground. In constructing a power system which will rapidly come online, two basic structures may be utilized, either independent power generation, which can be rapidly transported to a disaster area to provide power, such as mobile generators, and stationary on-site units which can come online when the national grid stalls.

Independent Power Generation

A deployable DEA system is composed of independent power generation units deployed to the disaster area to power critical applications during the aftermath to provide emergency services to the afflicted community. These units can be of help during a disaster by being placed online at a structure to help meet its peak power or base load needs during the crisis.[45] Utilizing DEA units during normal conditions has the benefit of being cost effective by allowing it to recoup the utilization cost by being in constant use, if there is a problem with the unit, it will tend to be discovered and repaired when everything is functioning normally, and not in the middle of an emergency.

Governmental authorities should site these units near critical areas (i.e. hurricane prone areas) that would allow rapid deployment with minimal post-event travel time. A typical deployable DEA would be a trailer-mounted natural gas fired generator. Each of these units is able to deliver up to 15 Megawatts, which would be a significant help in a disaster area.

Stationary Decentralized Energy Assets

Stationary DEA has the benefits of being able to meet a critical facilities regular energy demand, and can serve as reserve generation as well when grid power is lost.[46] Some of the most prevalent systems that are used are the Combined Heat and Power (CHP) systems and Photovoltaic systems. The combined heat and power generation systems generally utilize three major categories of technology; combustion turbines, engines, and fuel cells.[47]

This DEA utilizes equipment that will allow the system to function independently of the grid after a disruption, whether a terrorist attack, natural disaster, or blackout. The primary feature of this is that the system is able to island (i.e. separate) itself from the grid and function independently in the immediate aftermath of a disruption.

It is necessary that this equipment be buttressed with energy storage, smart technology, and high speed switches that will be able to rapidly cut off non-emergency applications to preserve power demand for critical functions. A key to stationary DEA is that it promotes stability by providing continuous power.

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[45] Doug Hinrichs, et al, *Protecting Critical Energy Infrastructure and Helping Communities Recover from Disaster with Distributed Energy Assets*, U.S. Department of Energy: Distributed Energy Program (2005)

[46] For a general understanding of the size and cost of these units, see, generally, *Power Generation*, Stewart and Stevenson. Available at <http://ssss.com/Literature/documents/STEWARTANDSTEVENSON POWERGENERATION.pdf>

[47] For a detailed discussion please see *Combined Heat and Power for the Northeast*, Northeast CHP Application Center. Website available at <http://www.northeastchp.org/nac/businesses/power.htm>

Conclusion: Recovering from Disaster

In the moments after a disaster, the most critical facilities have only a short time window before they are damaged by the power loss. DEA, if constructed with foresight, and the right mix of deployable and stationary assets, can protect vulnerable communities, and assist in regular operations for critical facilities used to help the community normalize quickly. However, in terms of power generation, power generators that run on diesel are not the best option. In addition to concerns of expansive use of fossil fuels, after a major disaster it is often quite difficult logistically to obtain fuel to power these generators. Diesel fired generators are dependent on access to fuel, which as starkly illustrated in the aftermath of Hurricane Katrina, its distribution was severely hampered.

The aftermath of the 2008 Hurricane Ike saw persistent gas shortages in the South that lasted for three weeks.[48] Former House Speaker Newt Gingrich, after a tour of the region, compared conditions in Atlanta, Charlotte, and Chattanooga to a "third world country." Gingrich's categorization of the conditions is not mere hyperbole; the most advanced countries can revert to a very primitive state without access to the energy which is as the lifeblood of the modern economy.

[48] The aftermath of Hurricanes Gustav and Ike in 2008 offers a good perspective as well on the psychological dimension of energy shortages. As soon as gas was delivered, anxious residents immediately filled up their tanks and gas cans. In this sense, the gasoline shortage was exacerbated by the residents' fear of a shortage. See Kate Brumback, *Weeks after Ike, Gas Scarce across South*, Associated Press (Sept. 30, 2008). Many behavioral researchers argue that human minds are hardwired to react in a certain way when they are frightened and faced with potential scarcity, which when acting collectively, is not in the best interests of society. See Erik Schelzig, *Sour Economy Tied to Psychology that Fed Gas Panic*, Associated Press (Sept. 28, 2008)